

6 June 2002
Munitions Industry Study

Munitions: An Industry in Peril

ICAF Seminar 10



The Industrial College of the Armed Forces

National Defense University

Fort McNair, Washington, D.C. 20319-5062

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 06 JUN 2002		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Munitions: An Industry in Peril				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) The Industrial College of the Armed Forces National Defense University Fort McNair Washington, DC 20319-5062				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 34	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

"It is the ability to destroy the target we are after, and in that case it is the munition, not the carrier, that is important."

Honorable Edward C. Aldridge, Jr., Under Secretary of Defense for Acquisition, Technology and Logistics

ABSTRACT

Munitions are a critical element of United States national security. The U.S. industrial base is able to produce high quality munitions that are the best in the world, but currently suffers from serious problems. Problems result from a steady decline in procurement funding over the past several decades, and systemic shortfalls in research and development funds. Efforts to stimulate efficiency have instead driven a long series of industry consolidations resulting in loss of competition and increasing corporate debt. Second and third tier suppliers have been eliminated, replaced by small niche companies with limited capabilities. The highly skilled munitions workforce and most government facilities are aging and not being effectively replaced. Program Manager efforts to promote efficiency by purchasing explosives, fuzes or components off-shore resulted in further damage to the domestic industry. Concerns exist that the lack of surge capacity may hazard U.S. security strategy for large-scale contingencies. Inadequate oversight by DoD and confused policies and generation of requirements by the services needs attention. Future systems will incorporate even greater precision and lethality, limiting U.S. casualties and collateral damage. Autonomous weapons, requiring minimal human intervention and the potential for directed energy weapons might someday make the munitions of today obsolete. The U.S. must decide if we will support our struggling industrial base or if we should look to overseas sources of munitions, accepting risks inherent in globalization. Whatever the future holds, munitions will remain a key element of U.S. military power for decades to come.

SEMINAR MEMBERS

Ms. Sonia Carlton, Department of the Air Force
Mr. James Kwolek, NIMA
Ms. Sue Lumpkins, Department of the Air Force
Lt Col Peter Maunz, U.S. Air Force
LTC Peggy Carson, U.S. Army
Mr. William Smith, Department of the Army
CAPT Richard Kiser, U.S. Navy
Lt Col Sam Kyle, U.S. Air Force
CDR Robb Rupp, U.S. Navy
CDR Jerry Manthei, U.S. Navy
Mr. Douglas Erwin, Department of the Air Force
Mr. John White, Department of the Air Force
Lt Col Bryan "Buck" Rogers, U.S. Air Force
COL Allan Vosburgh, U.S. Army
Col Ed McDermott, U.S. Air Force

FACULTY MEMBERS

CAPT Susan Maybaumwisniewski, U.S. Navy
CAPT Brian Blanchfield, U.S. Navy
Dr. (COL) Robert Roland, U.S. Army
Dr. Gerald Berg, ICAF Faculty
Dr. Frank Cooling, ICAF Faculty

PLACES VISITED

Domestic:

Lockheed Martin Corporation, Orlando, Florida
Raytheon Missile Company, Tucson, Arizona
Air Armament Center, Eglin AFB, Florida
Dayron, Orlando, Florida
STRICOM, Orlando, Florida
Naval Surface Warfare Center – NOS Indian Head, Maryland
Defense Threat Reduction Agency, Arlington, Virginia
National Imagery & Mapping Agency, Washington D.C.
Talley Industries, Phoenix, Arizona
Infoglyph and Six Sigma, Tucson, Arizona

International:

European Aeronautic Defense and Space Company (EADS), Munich, Germany
IABG (Industrieanlagen-Betriebsgesellschaft mbh), Schrobhausen, Germany
Thales, UK (Msl & Elec)
UK Ministry of Defense (TLAM, IPT), London, England
UK DSTL (Defense Science Board), London, England
U.S. CINCNAVEUR J3, London, England

INTRODUCTION:

The munitions industry in the U.S. is key to U.S. national security strategy and a vital component of the military element of national power. Including all types of munitions, from pistol ammunition to nuclear weapons, these are critical components of our security portfolio and provide the ability to influence world events. The U.S. has developed the most advanced weapons in the world, incorporating unsurpassed lethality and pinpoint precision. Despite this significant lead in munitions technology, the U.S. munitions industry developed serious industrial base problems that could eventually erode our ability to project adequate military force in support of the informational, economic and diplomatic elements of power.

A basic logistics premise is that during peacetime we value efficiency and during wartime we value redundancy. Nowhere is this truer than in the munitions industry. The concept of time-sensitive supply when applied to wartime munitions can be disastrous if the right munitions in the right quantities are not available in the right place at the right time. Requirements must be accurate and coordinated to prevent wasting vital and scarce resources. Manufacturers must be capable of producing or buying components in quantities adequate to meet both peacetime and national crisis goals. Physical facilities must be adequate and skilled workers available to meet requirements. Lastly, sufficient funding must be provided to support private industry in a competitive free market economy, modernize government facilities, and pursue research and development.

In search of efficiency, the U.S. munitions industry has undergone a long series of consolidations. Government and contractor facilities closed or downsized and skilled workers were lost to retirement or other industries. The munitions industrial base, which existed after World War II, is now a shadow of its former capability. Military depots and arsenals, capable of producing millions of rounds of ammunition and bombs, are in serious need of recapitalization.

The Munitions Seminar specifically questions the ability of the munitions industry in the U.S. to meet the challenges of producing adequate legacy munitions to support near term operations, while transforming to support precision engagement in the context of Joint Vision 2020. What risk is the U.S. willing to assume in pursuit of efficiency? Can we achieve unity of effort within the U.S. munitions industry and with our key allies and coalition partners?

We have focused on the overall munitions industry and not on specific types of munitions. Missiles and precision-guided munitions (PGM's) dominated many of our discussions because they are the central focus of current and recent military operations. It is appropriate that PGM's dominated our look to the future since they are such a vital component of transformation and precision strikes. We included discussion of directed energy weapons as a follow-on capability to PGM's for the objective force. We purposely did not include discussion on nuclear or other weapons of mass destruction in order to focus on conventional ordnance issues.

A tough question is whether the U.S. will continue to develop and produce the vast majority of munitions domestically, or partner with foreign producers to provide munitions needs. Globalization suggests that engaging the world market could provide enhanced efficiencies and economies of scale. However, the risk of inadvertent or intentional failures in the international system to provide vital munitions may be too great to accept. Greater use of world markets would almost certainly accelerate the demise of some domestic munitions companies as a cost of doing business. Gaining consensus on this issue is problematic at best.

Overall, the industry is presently capable of producing quantities of high quality munitions adequate to support peacetime needs or Small Scale Contingencies (SSC). Concerns exist regarding corporate health of the munitions industrial base and its ability

to surge to meet major theater war or large contingency requirements. The apparent lack of a centralized munitions vision within DoD, aging facilities and a graying workforce make the government's future high technology capability questionable. Increased industry reliance on a dwindling number of second and third tier suppliers of critical munitions components puts the surge capacity for high technology - low volume precision munitions at risk. Regardless of the type of munitions discussed, similar concerns permeated our studies of the munitions industrial base.

Finally, we will outline policy recommendations that might improve the overall situation. Munitions provide the lethal punch necessary to the credible use of the military component of national power. If we fail, there will be no second chance to provide the best munitions available to our warfighters. Transformation success relies on better, more lethal and more precise munitions. The ability of the services to maintain near-term force readiness relies on our approach to acquiring munitions and managing the industrial base that produces them.

THE MUNITIONS INDUSTRY

The munitions industry is difficult to bound as it encompasses both governmental/military elements and commercial businesses. Munitions encompass a wide continuum of products ranging from simple to complex weapons. The industry includes everything from small arms ammunition to mines, mortars, artillery ammunition, demolition materials, large rockets and missiles. It also includes bombs and nuclear weapons. Additionally, the industry includes all subcomponents such as pyrotechnics, propellants, fuzes, power supplies and guidance systems. Recent experiences in Iraq, Kuwait, Bosnia, Kosovo and Afghanistan shifted much of the industries' emphasis from traditional low technology munitions to precision weapons. Precision munitions support U.S. strategies by limiting friendly casualties and minimizing collateral damage.

The trend to use precision munitions is even more pronounced as we transform in support of precision engagement as described in Joint Vision 2020. Recent operations in Afghanistan validated the effectiveness and value of air delivered precision-guided munitions (PGM's). Extensive use of PGM's in Afghanistan revealed shortfalls in our requirements determination process and the munitions industry's ability to rapidly manufacture adequate supplies to support the Combatant Commanders' choice of weapons.

CURRENT MUNITIONS INDUSTRY CONDITION

Joint Vision 2020 identifies the need for the U.S. to begin preparing now for an uncertain future. To accomplish this task, the U.S. military must obtain full spectrum dominance using superior munitions systems capable of precision engagement at any time and in any place in the world. Precision munitions will be key to accomplishing the goals of Joint Vision 2020.

The current state of the munitions industry can best be described as bimodal. At one end, precision-guided munitions have enjoyed unprecedented success and positive publicity. The nightly news showed continuous pictures of PGM's landing on target in Bosnia, Kosovo and Afghanistan, emphasizing the advantage the U.S. military employed with such precision munitions. On the other, the U.S. munitions industrial base is struggling to stay afloat and keep pace with DoD and public expectations.

CURRENT MARKET CONDITIONS

From a market perspective, modern munitions, especially PGM's, are very specialized products. They may not be purchased as commercial, off the shelf products and generally have no commercial applications. The munitions market is global in nature and it is highly competitive. The munitions industry is by definition a monopoly/monopsony, with usually one main seller and one buyer – the government.

During the 1980's, DoD engaged in an unprecedented military build up. Included in that build up was development of new precision missile technology and the subsequent production of that technology. As long as the Soviet Union loomed large on the horizon as a threat, new weapons and new technology was an imperative. Companies competed for the lucrative defense contracts. As well, duplication was tolerated as a method to produce the best product and create competition among the missile manufacturers.

With the collapse of the Soviet Union, the U.S. turned its attention inward and defense budgets shrank. More recently, DoD has chosen not to afford redundancies, or invest in research and development, preferring to buy near-term readiness (See Figure 1).

Munitions Budget Pre - 9/11

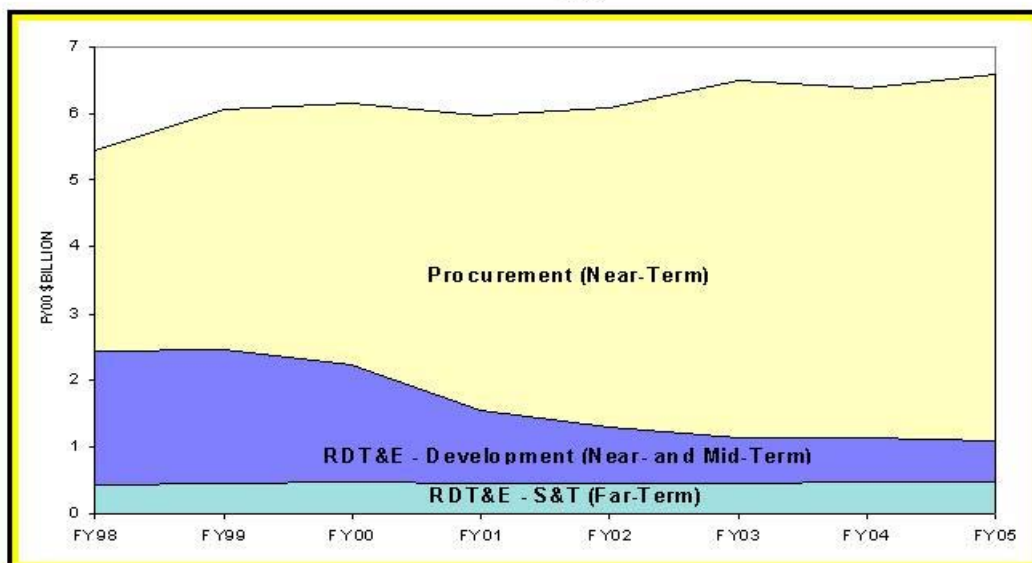


Figure 1

While overall defense spending increased overall since 9-11, procurement of near-term munitions needs have reduced funds available for near and mid term R&D even further. During an infamous 1993 meeting generally known as the “last supper,” Secretary of Defense William Perry told defense industry leaders that if they persisted on their current course, the defense market would not be large enough for all of them to survive. Beginning with twenty-two companies, massive consolidations followed over the next ten years, directly affecting the munitions industry and resulting in only four large U.S. firms (See figure 2).

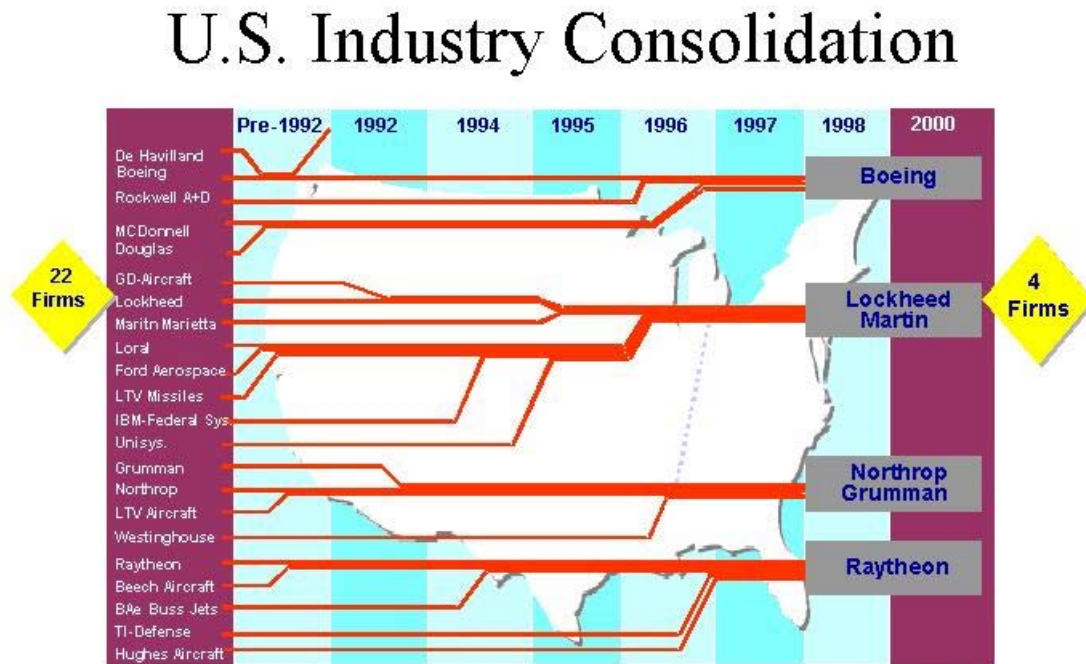


Figure 2

In 1998, the trend toward consolidation slowed when a proposed merger of Lockheed Martin and Northrop, and the acquisition of Newport News shipyards by General Dynamics were disapproved. The government realized the pendulum had swung too far toward consolidations and that real competition was in jeopardy.

Business Environment

Due to substantial debt resulting from consolidations, credit ratings of major U.S. defense vendors slid to nearly junk bond status. Long-term ventures with sub-vendors are difficult to establish due to single year defense budgets, lack of long term government contracts and a general fear that the defense department will not “come through” with the next contract option. Risk to DoD became apparent early during Operation Enduring Freedom, when Boeing was asked to dramatically increase (surge) production of Joint Direct Attack Munitions (JDAM’s). Primarily due to the unavailability of components from second and third tier suppliers, Boeing estimated at least six months to achieve

desired JDAM production levels. Because of limited war reserve stocks of JDAM's and the overwhelming success of their employment during the initial phase in Afghanistan, JDAM had become the weapon of choice during nearly every air-to-ground engagement, driving the limited stockpile dangerously low. Running out of JDAM's would mean using some other, perhaps less precise munition, with potentially increased risk to ground forces or aircrews.

The consolidation issue did not stop with just prime vendors. With a lack of funding to sustain long-term contracts, second and third tier vendors also consolidated or disappeared. Additionally, a number of single vendors collapsed from low profit margins. Although DoD policy makers in the early 1990's viewed consolidation as an effective management tool for industry, the subsequent negative effects of loss of competition, decreasing budgets, lack of long-term contractual commitments and disappearing vendors are now evident.

Overall assessment of DoD's munitions planning and fighting strategy can best be described as follows:

- Uncertain production capacity.
- Uncertain demand and inflexible DoD procurement practices (and budgets.)
- Inefficient information management (of reserves and requirements.)
- Aging and uncertain workforce (for both government and contractors.)
- Vendor/sub-vendor lack of responsiveness.
- Degradation in surge/mobilization capability.

European Consolidations

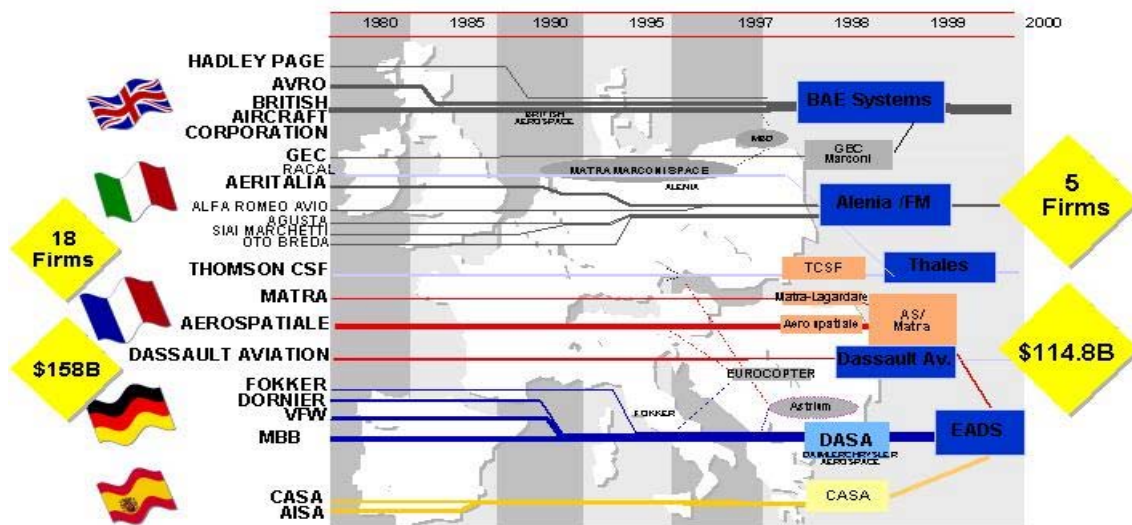


Figure 3

International Environment

Not unlike U.S. industry, European munitions producers faced many similar challenges. Shrinking budgets, defense industry consolidations (Figure 3), and European Nationalism (EU) presented similar issues. Major European munitions suppliers accomplished an assessment in 2001 of the global PGM market. The assessment concluded that U.S. PGM producers dominated sales both in the U.S. and overseas. The U.S. provided 97% of the PGM's for the U.S. and 67% of the PGM's in the rest of the world. The U.S. firms were successful in promoting policies that provide subsidies (in the form of R&D funds) and laws that block or heavily restrict sales of foreign produced products to DoD (The Buy American Act, Section 806, of the Strom Thurmond National Defense Authorization Act for FY99 and the Defense Export Loan Guarantee Program) by European companies.

To gain the ability to compete in the larger U.S. market, BAE created BAE North America, a U.S. Corporation wholly owned by BAE systems, a United Kingdom company. BAE North America successfully purchased several U.S. companies, and positioned itself as a large and financially sound U.S. defense contractor. By leveraging its physical location in the U.S., it is a viable competitor for some U.S. companies. As well, other international corporations are opting to form partnerships and similar ventures to break into the U.S. market.

Government Oversight and Policy

If you asked for a total DoD requirement for munitions, you would be hard pressed to find a single answer. No one person or office integrates the total DoD requirements process, determining the types and numbers of munitions required by the services over the POM. Each service develops their own requirements, contracts for production and takes individual delivery of munitions. When a Combatant Commander needs to move munitions to support a regional contingency, more than one service is usually involved. The total (worldwide) inventory of any given PGM or missile is not readily available to that Combatant Commander to help in the decision making process.

Summary

Smart munitions, specifically air-dropped PGM's, are the weapons of choice for the immediate future. No one can deny the well-publicized success achieved by the U.S. in the last four conflicts (beginning with Operation Desert Storm) and PGM's fully support the public's demand for low U.S. casualties and minimal collateral damage. However, in spite of these accomplishments, there is eminent danger to the munitions industry. The prime contractors are heavily debt ridden from a decade of consolidations. They cannot depend on DoD for long-term contracts and have difficulty establishing long-term support relationships with sub-vendors. To satisfy the requirement for competition, the munitions budget must be sufficient to at least maintain the current industrial base. In the aftermath of 9-11 and as Operation Enduring Freedom continues,

money to replace PGM's expended in the war will help the industry in the short run. In the longer term, we cannot overlook competition from Europe and their desire to enter the financial race for new U.S. contracts.

There is great concern that DoD or the Joint Staff lacks a single office for integration and oversight of the total munitions program. Without a DoD roadmap for munitions policy, Congress will continue to pass laws such as Section 806 of the FY99 National Defense Authorization Act.¹ However, support for the U.S. military may not rest entirely on American companies. Increasingly, the U.S. fights as the leader of a coalition, but the growing inequality of weapons and munitions puts the future of these coalitions in jeopardy. Many coalition partners are becoming more vocal in making their point that interoperability with U.S. forces does not always mean buying American munitions. Until DoD addresses this issue, much of the munitions industrial base will continue to chase market forces— which may or may not be the best way to serve the overall DoD mission.

FUTURE ISSUES

There is no single solution for concerns within the munitions industry. Rather, the U.S. government and private U.S. companies engaged in the munitions business must address the following series of issues.

Strategic Planning

Today, we lack strategic planning for munitions within the Department of Defense. We desperately need an overarching roadmap toward munitions as an industry and an overall DoD requirement. We must develop goals to adequately plan a long-term budget, a roadmap toward the future, a plan for today, and the R&D investment to achieve the roadmap. The planning process must include alternatives to allocate scarce resources in time of national emergencies. If DoD is serious about efficiently and effectively managing munitions, it needs to adopt a systems approach to ensure it supplies the war fighter with the proper number and type of munitions they need to win wars as outlined in Joint Vision 2020.

DoD must formulate a strategic roadmap to identify munitions requirements and priorities among the Combatant Commanders and establish service component goals for munitions research, acquisition transformation and overall munitions management. The strategic plan must be supported by a complimentary budget that enables DoD to reach goals established by the Combatant Commanders. Stabilizing budgets also enables prime contractors to enter into more stable long-term agreements with their vendors.

¹ Section 806 of the Strom Thurmond National Defense Authorization Act of FY99 seeks to protect the domestic munitions industry by specifically requiring program managers to have procurements of propellants, explosives, fuzes, and other critical munitions components reviewed and approved by the Single Manager for Conventional Ammunition (SMCA). The SMCA, currently the Secretary of the Army, is required by law to protect the interests of the domestic munitions industry and to insure program managers are not buying overseas when U.S. companies can provide required components at reasonable cost.

Policy Guidance

The U.S. government needs to streamline restrictive import and export regulations executed by the Departments of State, Defense and Commerce. U.S. munitions producers have experienced export delays due to export license application processes and approval procedures causing shipping delays, increased costs and reduced revenue. Foreign customers will go elsewhere rather than subject themselves to excess delays. Conversely, foreign sources that could shore up our own munitions manufacturing shortfalls meet with the same excessive “red-tape” and delays.

There is some reason for optimism regarding changes. According to a senior-level Pentagon official, "... export licenses for systems sold to U.S. allies since the start of Operation Enduring Freedom have been processed in as little as 24 hours. There is evidence that the system can respond when necessary...."²

Business Strategies

To enlist corporate investments in munitions research, development and production, DoD should stabilize the prime and sub-vendor production base by negotiating long-term pricing agreements and entering into multi-year contracts. This would provide the needed guarantee for second and third tier vendors to remain active and viable in the market. Rather than focus on the cost of munitions, DoD should pay for the value of the weapon being produced and maintain a warm industrial base. Multi-year contracts based on best value will ensure the prime's ability to remain in the market, keep a warm production base, and maintain a long-term relationship with the sub-vendors.

Information Management

Technology moves with the speed of thought. Advances in technology, the advent of the global marketplace and the emphasis on knowledge management, makes overall information management a “must pay” for the future of the munitions industry. The efficient management and utilization of information will provide flexibility and efficiency to optimize production capabilities. Information management resources and management can be leveraged so intellectual capital and knowledge flow across DoD, prime contractors, and second and third tier vendors (U.S. and global suppliers) networks. Networks which integrate requirements, budget projections, parts availability, contract coverage and warehouse locations and shipping data will be the lynchpin for true enterprise management of munitions in the twenty-first century.

Maintaining Industry Skills

The munitions industry (both government and private) has experienced a serious loss of experienced workers. Part of this "brain drain" is due to the advent of lean logistics, reduced inventories and people, downsizing of the defense budget and debt

² Elizabeth G. Book, Ed., "Export Licenses for U.S. Allies in 24 Hours?" National Defense Magazine, May 2002: 7.

incurred via buyouts and acquisitions within the industry. Decreases in R&D funding and overall defense budgets have driven skilled workers into retirement or other businesses. The munitions industry must build flexibility into the workforce. This will enable the industry to use multi-skilled workers to handle surge requirements, and ensure employment because multi-skilled workers can move to other production lines. This will involve an investment in training by both government and industry to develop multi-skilled workers. Along the same vein, capturing employee intellectual capital in a database could help offset the “graying of the workforce.” Conversion of tacit knowledge into explicit knowledge should be leveraged by each service, across the munitions industry and throughout the munitions supply chain.

Collaboration and Partnering

Collaboration with universities, research labs, industry and allies provides a valuable source of research and development, innovative thinking and possibly a new source of employees for the munitions market. DoD and prime contractor teaming could help second and third tier vendors remain in business by providing longer lead-time on production requirements and improved inventory management. It could also provide efficient use of industry capacity and decrease duplicative infrastructure requirements.

Improved Business Practices

The PPBS system needs to change, increasing the use of multi-year contracts without threatening congressional oversight. This change will entice contractors to risk more of their own money (or other assets) in munitions programs without fear of bankruptcy. A constant funding stream is preferred over the “feast or famine” policy we have today.

Summary

The challenge is to leverage munitions industry technological success while much of the industry is on the brink of financial insecurity. The U.S. government should seriously consider the areas outlined in this section. U.S. national security can best be served by a viable, healthy munitions industry. Without an adequate quantity (and a strong reserve) and quality of flexible munitions, our ability to meet current and future challenges will be severely tested. The conflict in Afghanistan, so soon after operations in Kosovo and Bosnia, should be a wake-up call regarding our ability to surge in such a critical industry. Without a strategic plan, an improved requirements process, a short and long-term budgetary plan, and strategic partners, we will continue to be stressed to find solutions to support our war fighting forces at home and abroad.

ESSAYS ON MAJOR ISSUES

R&D and Future Munitions Systems

Joint Vision 2020 states “[the U.S.] needs to prepare now for an uncertain future” and establishes four key tenets for the transformation of the services; “dominant maneuver, precision engagement, focused logistics, and full dimension protection.”³ Precision munitions are one of the keys to meeting JV 2020's goals. The need for precision engagement over the next two decades drives munitions research and development (R&D) down a relatively narrow path. The focus of R&D in the munitions industry is to increase the effectiveness and efficiency of bombs, missiles, and projectiles.

Current and near-term air-dropped systems such as the Joint Direct Attack Munition (JDAM), Joint Stand-off Weapon (JSOW), Joint Air to Surface Standoff Attack Missile (JASSM), and Standoff Land Attack Missile-Expanded Range (SLAM-ER), as well as surface fired missiles like the Tomahawk Land Attack Missile revolutionized air warfare. Artillery systems like Low Cost Competent Munitions (LCCM)⁴ add near precision to existing mortar and artillery rounds. Developing precise tube fired systems for both ground and sea based platforms will provide more precision and lethality in smaller packages and reduce unilateral reliance on air delivered systems.

Some day, directed energy may come to replace chemical energy as the basis for weapons. Directed energy allows the precision use of exactly the amount of lethality needed to accomplish our objectives, essentially eliminating collateral damage. If, and when, this technology becomes possible, the munitions industry as we know it today will change forever.

The conflicts of the future will always be fought on the world media stage. Every civilian casualty, every loss of an airman, soldier, or sailor, and every incident of collateral damage will significantly affect U.S. and world opinion. The U.S. must focus on technologies that:

- Provide extremely precise weapons minimally affected by jamming.
- Have a near zero failure rate.
- Provide effective combat power without risking the lives of warriors or civilians.
- Can defeat an enemy without totally destroying the infrastructure of their society.

These conflicting goals can be handled by advanced technologies that exist or are on the near horizon. The U.S., as the sole remaining superpower, must continue to modernize its weapons and weapon systems if it is to meet the asymmetric threats of the future.

³ Director of Strategic Plans and Policy, “Joint Vision 2020,” U.S. Government Printing Office, Washington DC, June 2000.

⁴ Low Cost Competent Munitions (LCCM) are standard artillery and mortar projectiles fitted with fuzes incorporating electronic technology making the rounds much more accurate by providing steering capabilities significantly reducing CEP.

Infrastructure Support

In recent decades, DoD widely embraced modern technology as a means of enhancing the military services' offensive and defensive capabilities. For the munitions industry, this encouraged increased development of precision munitions. The potential for increased use of autonomous weapons such as PGM armed unmanned vehicles in the future increases reliance on supporting infrastructure technologies. A large portion of the supporting infrastructure technology for munitions is geospatial technology. Geospatial technologies are images, geospatial information, and the Global Positioning System (GPS).

From a strategic perspective, and in contrast to the munitions industries, geospatial technology industries are clearly in a dual-use environment. The political, economic, social and technological issues are vastly different. Political policy recommendations for their use and protection are coordinated outside the DoD/Intel controlled munitions community as the technologies are embedded in commercial products. This dual-use approach allows the geospatial technology industries to enjoy a more robust economic scale. The social element of national power is pushing U.S. society towards an antiseptic war. Finally, the technology imperative of the U.S. forces American's geospatial technology industries to keep abreast of improvements. The future trends indicate an emergence of directed energy weapons and Unmanned Aerial Vehicles (UAV's). These advancements will use key geospatial technologies.

In the final analysis, the geospatial technology industrial base has grown robust through effective policy and a dual-use commercial approach. It provides military advantages and satisfies the social concerns of reducing collateral damage and loss of life. Additionally, key skills and mobilization capabilities are now embedded in the general population and the industrial base respectively. To date, the munitions industry has not followed this approach and is suffering from lack of cohesive policy and a shrinking industrial base.

High Performance Explosives (HPE) Industry Summary

Despite a clear national security need to maintain a strong domestic high performance explosives production capability, the U.S. government does not have a consistent strategy to accomplish that end. Procurement policies that favor lower cost imports without consideration for overall "best value" for long-term U.S. national security interests repeatedly contradicts stated DOD intentions regarding maintenance of a national high performance explosives industrial base. DoD Program Managers' repeated selection of foreign HPE suppliers operating facilities with limited production capacities was a prime motivator for Congressional passage of Section 806, continues to damage the U.S. production base. This pure "best price" approach is inconsistent with DoD's simultaneous ownership of the U.S. Army Ammunition Plants that dominate domestic HPE production. Clearly, a part of DoD sees these plants as the best means to retain a U.S. HPE industrial base capable of meeting both peacetime and wartime production demands, however the procurement community is not in step with this view.

Their decisions have undermined the economic viability of the largely government-owned, contractor-operated plants and put wartime HPE production capability at risk.

DoD should conduct a complete review of existing government-owned HPE production facilities and determine what level of excess capacity is appropriate for future peacetime and potential wartime needs. DoD should close any excess facilities in accordance with the provisions of the 1956 Arsenal Act in order to enhance the viability of remaining government and private sector organizations. In addition, DoD should recognize that “best value” for U.S. national security needs would be best achieved by maintaining a viable domestic HPE/HPEC industry. It should determine a minimum level of domestic production necessary to support an adequate industrial base. Limited “Buy America” policies and all provisions of Section 806, of the Strom Thurmond National Defense Authorization Act for FY99 should be enforced to direct at least a minimum level of spending to U.S. facilities before using foreign sources. In addition, present levels of R&D funding are inadequate to fully develop and exploit the potential of new high performance explosive technologies. The decline of R&D funding has slowed development of advanced energetic materials, inhibited manufacturing process advances and eroded both the federal and private scientific research base. There is no DoD strategy designed to balance R&D funding between government and private industry and preserve critical research capabilities in both sectors.

War Reserves and Requirements

Munitions war reserves are a critical component of the Combatant Commanders ability to conduct war. There are currently stocks of munitions located in CONUS, at some overseas bases, and on prepositioned ships assigned to specific regions, but capable of moving anywhere in the world. These stocks are insurance against the possibility of no-notice war in unforeseen areas and against known shortfalls in strategic lift of needed munitions. Modern war does not allow the luxury of time to build-up munitions stocks to support the initial fight.

The key to effectiveness of war reserve stocks is the process used to determine requirements. DoD uses the Capabilities Based Munitions Requirements (CBMR) process to make this determination. A potential problem with this process is the variety of analytic tools and methods the services use to implement the CBMR. Poor requirements lead to inefficient procurement, storage and management. Second order effects include improper manning to handle munitions and inadequate transportation resources to move them. DoD has failed to ensure requirements actually reflect what we need to prosecute the joint battle. If requirements do not reflect reality, funding is even more in need of changes. Funding was insufficient for decades and some legacy stocks are beginning to fail due to lack of attention. This creates even more pressure on funds since it increases the need for demilitarization of unusable stocks.

Operation Enduring Freedom underscores the preeminence of modern U.S. munitions and the lesson most likely has not been lost on our enemies. However, over the last two decades, the munitions industrial base contracted significantly and many vital

subcomponent contractors are now virtually sole source. Recent media attention highlights several of these pivotal links in the munitions supply chain, and initial investigations into force protection aspects of these contractor facilities yield disturbing results. Had Al Qaeda terrorists engineered “industrial accidents” at critical subcomponent manufacturers before the 9/11 attacks, they could have significantly impacted U.S. military strategy. We must act to comprehensively identify all the “weak links in the chain” and to protect and/or back up these critical sources where possible.

Munitions are generally bought in the coming year for delivery two to three (or more!) years out. This means many of the newest munitions being dropped or fired in Afghanistan today were ordered in 1998 or 1999. Long lead times are typical for low density, high technology weapons. This presents some interesting questions regarding how many high tech weapons we should buy for war reserves. High costs dictate buying minimal numbers, but most are being used as fast as they are produced, leaving no excess for war reserves. Combatant Commanders in Unified Commands not engaged in contingencies are likely to be reluctant to release their stocks of PGM’s since there is no guarantee when they will be replaced. There should be a plan in place to accomplish prioritization of these critical assets.

Fuzes

“The Safing, Arming, and Fuzing (SAF) industry has been in sharp decline in the past decade. The perceptions that SAF devices employ mature technology, are easy to build, and are inexpensive has resulted in continual under-funding of research, development, testing, and evaluation by both industry and government. This fact, combined with a lack of production requirements, has resulted in an erosion of the SAF industrial base. Today, the number of companies capable of producing quality SAF devices is decreasing.”⁵

This report, written in 1990 remains relevant in describing the industry in 2002. In 1987, there were 31 firms engaged in fuze manufacturing. By 1991, there were 17.⁶ In 2001, the industry market overview listed eight fuze production facilities that employed less than 1700 people and generated total revenues of \$252 million.⁷ A combination of cultural and market forces continue to downsize the fuze industry to a tentative four or five production lines.

Fuzes are essential elements in every artillery projectile, rocket, bomb, missile, and torpedo used by the military. A fuze is designed to provide the safety and arming functions necessary to preclude activating a munition’s lethal effects before the desired position or time. It must accurately sense a target or respond to prescribed conditions,

⁵ David Dierolf and others, “DoD Fuze Industry Workshop,” IDA, April 1990: 1.

⁶ Phil Gorman and Cindy Medinger, “Advanced Planning Briefing to Industry (APBI) for Fuzes,” briefing 14 February 2001.

⁷ “Fuzing Industrial Base and Market Overview” brief to Industrial Committee Of Ammunition Producers, 12 February 2002.

such as elapsed time, acceleration forces, or command to initiate a train of fire or detonation in a munition.⁸

Fuze production is primarily accomplished in small facilities that specialize in niche products. As defense companies downsized in the 90's, many of these facilities were closed and product-lines and technologies sold. One of the most significant impacts to the U.S. fuze industrial base occurred in 1997, when ATK purchased Motorola's fuze division, along with the technology for the Hard Target Smart Fuze (HTSF). Motorola's engineers chose not to transfer and technical expertise was lost. Consequently, HTSF has yet to achieve required objectives. Likewise, L-3 Communications (a new company to fuzing production) purchased Bulova's fuzing division and experienced similar expertise gaps in pursuing high reliability in the Army's Self Destruct Fuze technology for sub-munitions.⁹ In combination with an aging workforce that is retiring without recruiting new talent, the loss of experienced engineers and scientists is the greatest threat to sustaining an industrial base that can produce reliable fuzes. Research and development is expensive with no current modeling and simulation capabilities or databases that can effectively fill this knowledge gap.

In summary, with DoD budget and buying habits focused on big-ticket items, fuze producers downsized to match demand, resulting in elevated risk to the munitions industrial base. DoD needs to plan fuze acquisitions and expenditures to promote stability and new development in the industry, while validating technology infusions with more credible databases. DoD and industry need new talent to replace an aging workforce. Finally, careful consideration must be given to any plan to buy fuzes offshore given the fragility of the domestic base. For fuzes, full compliance with Section 806 is a must if a domestic fuze production industry is to be maintained for the future.

Export Controls, Foreign trade, and Harmonization

In the U.S., the controlling regulation for munitions is the Arms Control Export Act. The Department of State administers this control system. All NATO countries and Japan, as well as most other armament producing states, manage a munitions export control system of some form. In general, munitions export controls exist for national security reasons, although there are many occasions when an export is blocked because of political objections. Munitions export controls have become controversial in the U.S., largely due to a shrinking national defense budget and stiffer foreign competition as both procurement and R&D budgets have significantly declined.

⁸ Anthony J. Melita brief to U.S. DoD Fuze Integrated Product Team.

⁹ Bulova Technologies, "Safer Battlefield Ordnance in Sight," 15 August 2001, Press Release, <http://www.army-technology.com/contractors/ammunition/bulova/press1.html>, 11 February 2002.

The purpose of export controls is to deny actual and potential enemies access to technologies that are likely to increase their military threat. Among the relevant laws are the Arms Export Control Act, the International Traffic in Arms Regulation and the Export Administration Act, as amended. The State Department holds the reins on defense exports.

Contractor direct military sales (DMS) abroad and foreign military sales (FMS) through the government, benefits DoD through lower costs which result from the larger business base of our defense contractors; however, our export control procedures inhibit DMS and FMS sales. Allies openly complain that export controls impede defense cooperation and contribute to the technology/capabilities gap between the U.S. and its allies. On December 16, 1999, the Dutch Ambassador wrote a letter (signed by senior diplomats of 16 other states) to Secretary Albright stating that U.S. export controls seriously impede defense cooperation. “During the March-June 1999 intervention in Kosovo, U.S. export controls prevented allies from having sufficient numbers of precision guided munitions.”¹⁰

The export licensing system for U.S. munitions list items, both for technology and arms sales, is an arrangement that favors national security. The munitions list process is structured to ensure thorough vetting and review of any export.

Some of the leading executives within industry and the Department of Defense agree that changes in munitions markets, alliances and threats associated with globalization, mandates revisions in U.S. policies and acquisition procedures to ensure warfighters receive best military technology at best value. A “Blueprint for Action”, written by this panel of executives and officials, details specific recommendations related to addressing changes brought about by globalization:

“Cold War-era export controls and industrial policies threaten to hinder contractor’s ability to conduct the nation’s business in a global environment. Preventing companies from utilizing overseas facilities, suppliers, and partners, along with their technologies, and from exporting and importing products within reasonable bounds of security, harms competitiveness and induces companies to depart, or avoid, the defense market. This is true both for companies located in the U.S. and looking outward, and for firms based overseas looking inward to the U.S. In the long run, failure to form a common industrial base with U.S. allies will increase the cost to the U.S. of preserving critical industrial capabilities and could invoke damaging political consequences, as well.”¹¹

The panel’s prescription for mitigating these risks include:

¹⁰ Charles B. Shotwell, “Export Controls: A Clash of Imperatives,” Project on Globalization and National Security, Institute for National Security Strategies, National Defense University, 2001, CD.

¹¹ “AIAA Defense Reform 2001 – A Blueprint For Action,” DFI International, February 2001: 36-45.

- Revamp the export control process. The product, services and technology list needs to be screened to include only those items/services absolutely critical to national security. The excessive scope of products and services controlled creates unnecessary administrative burdens on industry and tension with allies. In addition, the current process takes much too long to accomplish and should be significantly streamlined to reduce processing time.
- Install an information system that gives all concerned agencies ability to track real-time status and expedite processing of export licenses.
- Move toward allowing industry to manage the export control system under government guidelines and audit procedures.
- Revise the State Department's munitions list to eliminate readily available, common, non-military unique items such as radios and avionics.
- Substantially reduce the list of items on the Commerce Department's Commodity Control List by tracking only those technologies where the U.S. and/or U.S. allies possess unique capabilities that can be controlled.
- Share information (to the maximum extent possible) with firms in friendly foreign countries, including consolidation of capabilities assessments.
- Streamline Treasury Department review procedures of proposed foreign/U.S. firm mergers.
- Permit the Pentagon to offer incentives for U.S. industry to seek out and propose joint technology acquisition programs with allied nations.

Probably the most enlightening recommendation of the panel was the emphasis that they placed on having our President aggressively pursue opportunities with NATO and other allies to “press for the harmonization of foreign ownership, anti-trust, and technology security regulations, as well as accounting standards, so as to foster a climate in which cross-border consolidation can take place more easily.”¹²

These recommendations are surprising when you consider the makeup of the panel - DoD Leaders and Industry CEOs that are normally expected to be more protectionist in their views. Of course, all industry and government representatives do not share their position and have lobbied diligently to maintain protectionist policies. This view espouses that the U.S. should maintain a protectionist policy toward transfer of technology to foreign countries. They contend that it may be acceptable to allow foreign firms to produce critical munitions or munitions components when no U.S. producers are available. Policy should not be to continue reliance on foreign firms and to develop

¹² Ibid.

resources in the U.S. to produce these items. These groups have lobbied successfully to place legislation on the books that severely restricts procurement of munitions from other than U.S. sources.

Export Controls/Foreign Trade: Conclusions/Recommendations

The U.S. Government seeks to control the export of too many products, services, and technologies. This creates serious tensions with U.S. allies and places undue burdens on industry. Additionally, the processes for exercising these controls are antiquated, cumbersome, and far too slow for U.S. companies competing in the global marketplace. The Government needs to look at reforms such as reviewing the Munitions List to eliminate items that are not uniquely military in function. Additionally, the Government needs to condense the Commodity Control (dual-use) List, streamline the export license and approval process, and evaluate alternative areas of giving industry a self-policing role in administering the export control sector with government guidelines, monitoring and enforcement.

Cooperative efforts in establishing export controls policy will protect the transfer of defense related goods while promoting U.S. access to the global defense business. This access can result in significant savings through global market competitive pricing. A structured approach with our allies to standardizing export policies, reflecting our current environment, will create more logical export policies. Our national security strategy is based on teamwork with coalition partners/allies and cooperative acquisitions and efforts in developing export policies should be part of that strategy. Interoperability in our business processes may prove as beneficial as interoperability of our weapons systems. This new paradigm could be a key ingredient to the pursuit of transformation in DoD.

Clearly, maintaining a healthy munitions industrial base is critical to the U.S. economy and national security. Also, it is evident that globalization offers threats and opportunities that must be assessed and appropriate policies implemented to mitigate the threats and take advantage of opportunities. The U.S. proved especially adept at understanding these challenges and benefited economically and strategically from globalization in other sectors. The current administration's approach, to break down barriers that impede cooperative arrangements for munitions production with friendly foreign nations, reflects wisdom acquired through analysis of historical events and trends. We must assure industry that the U.S. will continue to support critical munitions producers with incentives necessary to secure their viability, but must recognize that the best interests of the country are served by allowing global markets to work efficiently. Many believe that in the long run, the best interests of all concerned are to maximize cooperation with foreign partners and allow competition to produce the best technology at the best value for our warfighters.

MUNITIONS INDUSTRY CONCLUSIONS

The munitions industrial base consists of many, varied components. These include both the organic base and the commercial base. The organic base is primarily made up of government facilities including the arsenals, ammunition plants (both government owned - contractor operated, and government operated), and munitions depots. The commercial base includes contractor owned facilities and numerous lower tier supply providers. The emerging munitions industry structure is technologically robust, but faces significant business challenges. A few large defense contractors that primarily serve as system integrators, develop and produce high technology products dominate that market. These large firms depend on declining numbers of their lower tier suppliers with sole source or unique expertise. Lower technology, high volume munitions are produced either at government owned, government operated facilities or by contractors operating in government owned ammunition plants.

In the 1990's, defense budgets plunged to historically low levels resulting in less competition and fewer munitions purchases. These diminished purchases created profitability problems for surviving munitions contractors who were already in debt from a series of consolidations. A decline in government research and development funds also jeopardized future U.S. technological superiority. Budgets for near term procurement have grown, but levels of support for near and long term R&D continue to decline. This trend must be reversed for the U.S. to retain leadership in high technology munitions.

This new environment presents significant challenges for DoD and creates an increasing need for coherent industrial base policies. These policies should address unity of effort among the services and where feasible, among allies. New policies should ensure adequate R&D funding, encouraging industry investment and collaboration to maintain current U.S. technological superiority. DoD must improve the munitions requirements generation process to avoid redundancy and maximize available resources. New policies should require improved integration of all services requirements and consolidation with allied requirements when possible. It is imperative that DoD encourages elimination of inconsistent and stove-piped service policies.

In the final analysis, the U.S. munitions industry is capable of meeting near-term, high quality munitions needs, but there is good reason to be concerned about the future. Without changes in our overall munitions policies, there will continue to be a substantial lack of surge capacity, especially for low volume, high technology munitions. The unstable, feast or famine natures of munitions procurements will likely drive second and third tier suppliers into even smaller and more specialized niches. The large systems integration companies will likely continue to experience supply-driven problems meeting requirements for high technology weapons, such as the requirement to surge JDAM production in 2002. A critical decision must be made whether to pursue a "Fortress America" approach, producing munitions domestically, or a globalization approach where we buy on the world market. There are risks associated with either approach. Public law (Section 806) currently impedes serious use of the global market for munitions. Any impact on this already fragile industry could cause adverse results on many companies. The munitions industry, unarguably producing the most critical war-

fighting commodity, is key to DoD's transformation and the long-term security of the U.S.

POLICY RECOMMENDATIONS

Establish a munitions integration agency within the Office of the Secretary of Defense (OSD) to monitor and harmonize munitions procurement programs.

- Conduct strategic munitions planning, creating unity of effort through development of a comprehensive DoD munitions roadmap that supports joint transformation. It requires integration of requirements planning, long term budget requirements, and would incorporate coalition and allied requirements when they can be determined. Service specific munitions such as PGM's are today not included as part of the SMCA portfolio. We would assign lead services for specific munitions areas, reducing duplication of effort. The office would also be responsible for integrating pre-planned wartime production priorities and establishing research and development plans and priorities.
- Develop a DoD business strategy encouraging stability across the munitions industry. Encouraging appropriate multi-year contracts and establishing "must pay" priorities ensures economic production quantities and can accomplish stability. The goal would be to reduce instability inherent in "feast or famine" production rates and schedules.
- Actively monitor key aspects of the munitions industrial base. This requires the OSD to identify and monitor the health of critical prime contractors, Government arsenals/depots and key lower tier suppliers. The DoD and prime contractors would be responsible for assisting second and third tier suppliers to ensure needed components. They would incentivize competition by qualifying alternate sources of supply, reducing the potential for single-point failures. These incentives would extend to encouraging production plant capitalization. Cooperative R&D efforts between DoD, industry and academia would be highly encouraged.
- Be the advocate for thoughtful, conscious policies promoting the U.S. munitions industry. This advocacy would impact areas such as streamlining export controls, making U.S. munitions easier to sell to other countries. It would also encourage review of import restrictions and overall import policies impacting munitions.
- Recognize that munitions are a unique sector requiring some level of excess industrial capacity to maintain required capabilities. This may be costly to maintain, but not as costly as failing to meet Title 10 responsibilities. Full spectrum dominance requires the ability to aggressively pursue any level of military action specified by the National Command Authority. Focus on the buyers, not the sellers. Recognize that the real focus is on what the government needs, not what the sellers need to do to compete.

- Promote Congressional support of needed spending to make war reserve programs relevant and effective. This necessarily has to include increased demilitarization costs for the 453,000 tons of obsolete or deteriorated munitions now taking up space in storage bunkers.¹³

¹³ Harold Kennedy, "Funds for Demilitarization Drop More than 30 Percent," National Defense Magazine May 2002: 28-29.

BIBLIOGRAPHY

“Aerospace & Defense Industry Profile.” US Business Reporter 22 December 2001.

“Air Force Science and Technology Challenges.” Inside the Air Force 25 February 2002.

Aladon Corporation Internet Site. “About Reliability Centered Maintenance.” Online. Internet. <http://www.aladon.co.uk/02rcm.html>.

Anton, P., Silberglitt, R. and Schneider, J. “The Global Technology Revolution.” RAND Report Prepared for the National Intelligence Council. 2001.

“BAE Systems, EADS and Finmeccanica Were Set to Sign Final Agreement.” Aviation Week & Space Technology 154.18 (30 April 2001).

Berkowitz, B.D. and Goodman, A.E. Best Truth, Intelligence in the Information Age. New Haven and London: Yale UP, 2000.

Bryen, Dr. Stephen D. “The Future of Strategic Export Controls.” Draft Paper. Online. Internet. 25 February 2002. <http://www.csis.org/export/articles/bryen.pdf>.

Bulova Technologies. “L-3 Communications Acquires Defense Business of Bulova Technologies.” Press Release. 19 December 2001. Online. Internet. 11 February 2002. <http://www.army-technology.com/contractors/ammunition/bulova/press3.html>.

Bulova Technologies. “Safer Battlefield Ordnance in Sight.” Press Release. 15 August 2001. Online. Internet. 11 February 2002. <http://www.army-technology.com/contractors/ammunition/bulova/press1.html>.

Bushnell, Dennis M. “The Shape of Things to Come?” Undersea Warfare Magazine 3.2 (Winter 2001). Online. Internet. http://www.chinfo.navy.mil/navpalib/cno/n87/usw/issue_10/bushnell_shape.html.

Carlson, Bruce Lt Gen, USAF, Director, Force Structure, Resources, and Assessment (J8). “Acquisition Process: The Joint View.” Briefing. 11 February 2002.

Center for Strategic & International Studies. “Defense Restructuring and the Future of the U.S. Defense Industrial Base.” A Report of the CSIS Senior Policy Panel on the U.S. Defense Industrial Base. Washington: March 1998.

Chong-saeng, Pak and Seol, Hangyoure. “Munitions Industry That Feeds on Blood, IANSA Participants Statement on War Against Terrorism.” 19 September 2001.

Conetta, Carl and Knight, Charles. "Defense Sufficiency and Cooperation: A US Military Posture for the post-Cold War Era." Columbia International Affairs 12 March 1998. Online. Internet.

Courter, Jim, Davis, L. Steve, and Thompson, Loren B. "US Military Ammunition Policy: Reliving the Mistakes of the Past?" Parameters Autumn 1994: 104. Online. Internet. 13 February 2002.

Crawley, James W. "Navy Outlines Goals for High-Tech Fighting Force of the Future." San Diego-Union Tribune 21 February 2002.

Davenport, Otha B., Director of Engineering for Air Force Propulsion Group, ASC/LP. Interview. 22 February 2002.

Deutch, John. "Consolidation of the U.S. Defense Industrial Base." Acquisition Review Quarterly Fall 2001.

DeYoung, Karen, and Pincus, Walter. "Anti-Iraq Rhetoric Outpaces Reality: Military Not Primed for New War Soon." Washington Post 24 February 2002: A.

Deyermond, BG John. "Ammunition Update to NDIA Fuze Conference." Briefing. 7 April 1999.

Dierolf, David and others. "Report on the Department of Defense Fuze Industry Workshop." Institute for Defense Analyses (April 1990): 2386.

"DoD Seeks Exemption From Submitting Industrial Capabilities Report to Congress." InsideDefense.com April 23, 2002.

"DTRA Needs Advanced Energetics, Novel Explosives." Navy News and Undersea Technology 13 November 2001: 26.

Ernst, Robert P., Head, Aging Aircraft Program. USN AIR-4.1D Interview. 6 February 2002.

Erwin, Sandra I. "Munitions Sector 'In Trouble' Despite New Funds." National Defense Magazine 5 March 2002: 1, 14-15, 86. Online. Internet.

Fiorenze, Nicholas. "Tank-Killing Howitzers." Armed Forces Journal International (April 2002): 26-27.

Flanagan, S., Frost, E., and Kugler, R. "Challenges of the Global Century, Report of the Project on Globalization and National Security." Institute for National Strategic Studies (2001).

Flamm, Kenneth. "U.S. Defense Industry in the Post-Cold War: Economic Pressures and Security Dilemmas." Peace Studies Program. Cornell University Occasional Paper #25. April 2000.

Frasier, J., et al. "Missile, Bomb, and Projectile Fuze Subtier Assessment." Institute for Defense Analysis April 1999: 258l.

Friedman, G. and Friedman, M. The Future of War: Power, Technology and American World Dominance in the Twenty-First Century. New York: St. Martin's Griffin, 1996.

Friedman, R. E. "Industry Surveys: Aerospace & Defense." New York Standard & Poor's 15 February 2001.

"Fuzing Industrial Base and Market Overview." Briefing to Industrial Committee of Ammunition Producers. 12 Feb. 2002.

Gholz and Sapolsky. "Restructuring U.S. Defense." International Security 24.3 (Winter 99/Spring 2000): 4-8.

Gorman, Phil and Medinger, Cindy. "Advanced Planning Briefing to Industry (APBI) for Fuzes." Briefing. 14 February 2001.

Gorman, Richard A., Lockheed-Martin Missiles and Fire Control. "ICAF Munitions Industry Study Seminar." Briefing. 8 April 2002.

Greenberg, Paul (Mg) (R), VP Operations. "National Defense Industrial Association, The Defense Industrial Base." Challenges for the 21st Century Briefing.

Henderson, Deborah. "Performance Measurement: The Data Warehouse Supports Best Practices." Ontario Hydro Services Company. Online. Internet. <http://www.business2.com/webguide/0,1660,51243,FF.html>.

Herbert, Adam J. "Supply Chain Visibility: US Air Force Adapts to War in Afghanistan and Learns Logistics Lessons." Armed Forces Journal International (April 2002).

Heskett, Jim. "Targeting Production Support NIMA." Brief. 8 February 2002.

Hesseldahl, Arik. "After the Attacks, New Attention on GPS." Forbes Magazine 2 October 2001. Online. Internet. <http://www.forbes.com/2001/10/02/1002gps.html>.

Holman, Barry. "Management of Naval Aviation Training Munitions Can Be Improved." FDCH Government Account Reports 27 July 2001.

India Ministry of Defense. Defense Research and Development Organisation. "Future Trends in Armament Technology". Vol. 9, No. 5. October 2001. Online. Internet. 11 February 2002. <http://www.drdo.org/pub/oct2001/trends.htm>.

Kosiak, Steven. "Buying Tomorrow's Military: Options for Modernizing the US Defense Capital Stock." csba. Online. Internet. 15 May 2001.

Kennedy, H. "Army and Industry Execs Plan Ammo Needs for New Brigades." National Defense Magazine March 2000.

Kennedy, Harold. "Funds for Demilitarization Drop More than 30 Percent." National Defense Magazine May 2002, pages 28-29.

"L-3 Communications Acquires KDI Precision Products." Precision Points Fall 2001.

"Less Bang From the Pentagon's Bucks." Business Week Online 29 March 2002.

Markusen, Ann, Senior Fellow, Council on Foreign Relations, Director, Project on Regional and Industrial Economics, Rutgers University. "Understanding American Defense Industry Mergers." Rutgers ORIE Working Paper #247. May 1997.

Melita, Anthony OUSD(AT&L)S&TS. "A Viewpoint From OSD." Interview. 27 April 2002. www.dtic.mil/ndia/2001fuze/1Melita.pdf

McManus, Major General Wade H., Jr. "Ammunition Readiness: The Operational Reality." Briefing to Industrial Committee of Ammunition Producers by the U.S. Army Operations Support Command. 12 February 2002. Online. Internet. 5 March 2002.

Melita, Anthony. "U.S. DoD Fuze Integrated Product Team." Briefing. 18 December 2001.

Mohanty, Debra R. "Defense Industries in a Changing World: Trends and Options." Strategic Analysis: A Monthly Journal of the IDSA 22.10 (Jan 2000).

Morrison, Matt R. Major, USMC. "The US Defense Industrial Base: Deterrence in Decline." 1990.

Motsek, Gary. "Ammunition Laydown Briefing." U.S. Army Materiel Command. January 2002

Munitions Industrial Base Task Force. "Annual Conference Briefing." Online. Internet. www.dtic.mil/2002munitions/palaschak.pdf

Muradian, Vargo. "Industry Surge Hampered By Parts Suppliers, Air Force to Help Speed Ramp-up." Defense Daily International 19 October 2001: 1. Online. Internet. 8 November 2001.

Muradian, Vargo. "Roche: Defense Industry Can't Bear New Consolidation: Gov't to play Larger Role." Defense Daily International 19 October 2001.

Nag, Arindam. "Pentagon Averse to Lockheed, Boeing Bid for TRW." Reuters Limited 12 March 2002.

"New Weapon Systems Are Budget Winners." Washington Post 8 February 2002.

Nicoll, Alexander. "Europe's Defense Spending Falling." Financial Times 17 May 2001.

Office of Strategic Industries and Economic Security. "National Security Assessment of the High Performance Explosives & High Performance Components Industries." Defense Market Research Reports 19 February 2002: 5. Online. Internet.

Ogden Air Logistics Center. "Laboratory Project 2001." Briefing.

Ostmeyer, Andy. "Military Reviews Battery Charges." The Joplin Globe Online Edition 9 January 2002. Online. Internet.
www.joplinglobe.com/archives/2002/020109/headline/story1.html

Palaschak, Rich. Briefing to Industrial College of the Armed Forces AY02 Munitions Seminar. 22 February 2002.

Patton, Phil. "Robots with the Right Stuff." Wired Magazine March 1996. Online. Internet. <http://www.wired.com/wired/archive/4.03/robots.html>.

Peltz, James F. "Mergers Remaking Defense Industry; Acquisitions: Rapid Consolidation is altering Competitive Dynamics and Drawing attention of Regulators." The Los Angeles Times 23 February 2002.

"Pentagon to Use New Bomb on Afghan Caves." CNN.com 23 December 2001. Online. Internet. <http://www.cnn.com>.

"Pentagon Transformation Causes Examination of 'Less Traditional' Supplier Base." Inside Defense 20 February 2002. Online. Internet. <http://www.INSIDEDefense.com>.

Pike, John. "AGM-154A Joint Standoff Weapon [JSOW]." Federation of American Scientists, Military Analysis Network 27 June 2000. Online. Internet.
<http://www.fas.org/man/dod-101/sys/smart/agm-154.htm>.

Pike, John. "AGM-158 Joint Air to Surface Standoff Missile (JASSM)." Federation of American Scientists, Military Analysis Network 20 December 2001. Online. Internet.
<http://www.fas.org/man/dod-101/sys/smart/jassm.htm>.

Pike, John. "AIM-9 Sidewinder." Federation of American Scientists, Military Analysis Network 23 April 2000. Online. Internet. <http://www.fas.org/man/dod-101/sys/missile/aim-9.htm>.

Pike, John. "AIM-120 AMRAAM Slammer." Federation of American Scientists, Military Analysis Network 14 April 2000. Online. Internet. <http://www.fas.org/man/dod-101/sys/missile/aim-120.htm>.

Pike, John. "Air Force Mission Area Plan, Annex F Common Solution." Federation of American Scientist, Military Analysis Network 15 November 1998. Online. Internet. http://www.fas.org/man/dod-101/usaf/docs/mast/annex_f/part26.htm.

Pike, John. "BGM-109 Tomahawk." Federation of American Scientist, Military Analysis Network 20 December 2001. Online. Internet. <http://www.fas.org/man/dod-101/sys/smart/bgm-109.htm>.

Pike, John. "BLU-118/B Thermobaric Weapon." GlobalSecurity.org 21 March 2002. Online. Internet. <http://www.globalsecurity.org/military/systems/munitions/blu-118.htm>.

Pike, John. "Hard and/or Deeply Buried Target Defeat Capability (HDBTDC) Program." Federation of American Scientists, Military Analysis Network 19 February 1998. Online. Internet. <http://www.fas.org/man/dod-101/sys/smart/hdbtdc.htm>.

Pike, John. "Joint Direct Attack Munition (JDAM)." Federation of American Scientists, Military Analysis Network 20 December 2001. Online. Internet. <http://www.fas.org/man/dod-101/sys/smart/jdam.htm>.

Pike, John. "Low Cost Autonomous Attack System (LOCAAS)." Federation of American Scientists, Military Analysis Network 29 November 1999. Online. Internet. <http://www.fas.org/man/dod-101/sys/smart/locaas.htm>.

Pike, John. "Small Smart Bomb." Federation of American Scientists, Military Analysis Network 29 November 1999. Online. Internet. <http://www.fas.org/man/dod-101/sys/smart/mmc.htm>.

Pike, John. "Wind Corrected Munitions Dispenser (WCMD)." Federation of American Scientists, Military Analysis Network 30 November 1999. Online. Internet. <http://www.fas.org/man/dod-101/sys/smart/wcmd.htm>.

Pyles, Ray, RAND Corp. Series of Aging Aircraft Briefings/Studies Presented by Project Air Force, March 2001.

Raytheon Missile Company. "ICAF Munitions Industry Study Seminar." Briefings. 5 April 2002.

"Report: Air Force Could Face Choke-Points in Precision Guided Weapon Production." Aerospace Daily 18 September 2001.

Robbins, Frank. "Fuzes for Air Force Unguided and Precision Guided Weapons." Briefing to NDIA Fuze Conference. 17 April 2001.

Roberto, Michael A. "Defense Consolidation Has Disappointed Shareholders." National Defense Magazine October 2002.

Shadley, Robert D., Alliant TechSystems. "ICAF Munitions Industry Study Seminar." Briefing. 22 February 2002.

Shalal-Esa, Andrea. "Defense Industry Mergers Pay Dividends – Pentagon." Reuters Limited 12 March 2002.

Shotwell, Charles B. "Export Controls: A Clash of Imperatives." Project on Globalization and National Security 2001. Institute for National Security Strategies, National Defense University CD-ROM.

Simpson, Randy. "Nanoscale Chemistry Yields Better Explosives." Science and Technology Review October 2000: 35.

Skibbie, Larry. "Fuze Industrial Base Problems Should No Longer Be Ignored." National Defense Magazine June 2001. Online. Internet. 24 February 2002.

Skons, Elisabeth. "Internationalization of the West European Arms Industry." Conference on Globalisation of Military Industry and Arms Trade. Middlesex University Business School, London. 19-20 September 1997.

Society of American Engineers. "SAE Standard JA1011: Evaluation Criteria for Reliability-Centered Maintenance (RCM) Processes." August 1999.

Sterk, Richard. "Terrorism Spurs Market to increased Funding and Accelerated Development." Forecast International 5 March 2002.

Thieret, Jeffery E., et.al. "Hit'Em Where It Hurts: Strategic Attack in 2025." Air Force 2025 Study, Air University Press. August 1996.

Tirpak, John A. "The State of Precision Engagement." Air Force Magazine 83.3 (March 2000). <http://www.afa.org/magazine/March2000/0300precision.html>.

Toffler, A., and Toffler, H. War and Anti-War, Survival at the Dawn of the 21st Century. New York: Little, Brown & Company, 1993.

United States. Chairman of the Joint Chiefs of Staff. Joint Vision 2020, Director of Strategic Plans and Policy. Washington: GPO, June 2000.

United States. Congressional Record (Senate). “Directed Energy and Non-Lethal Use of Force.” 20 March 2001: S2571-S2572. Online. Internet. <http://www.fas.org/sgp/congress/2001/s032001.html>.

United States. Defense Operational Test and Evaluation. FY00 Annual Report - Joint Air-to-Surface Standoff Missile (JASSM). Online. Internet. Washington: 20 March 2002. <http://www.dote.osd.mil/reports/FY00/airforce/00jassm.html>.

United States. Departments of the Army and Air Force. Military Explosives. Washington: DOD Press, 1967.

United States. Department of the Air Force. Air Armament Center. “Briefings to AY2002 Munitions Industry Study.” 22 March 2002.

United States. Department of the Air Force. Air Force Issues Book – Precision Weapons. Washington: 1997. Online. Internet. http://www.af.mil/lib/afissues/1997/app_b_8.html.

United States. Department of the Air Force. Air Force Chief of Staff. “Logistics Review.” 2001.

United States. Department of the Air Force. Air Force Material Command Briefing. “Bow Wave.” August 1999.

United States. Department of the Air Force. Air Force Material Command. “Supply Chain Managers Conference.” April 2000.

United States. Department of the Air Force. Air Force Research Laboratory. “Active Denial Technology, Directed Energy Non-Lethal Demonstration.” AFRL Fact Sheet. March 2001. Online. Internet. <http://www.de.af.mil/Factsheets/ActiveDenial.html>.

United States. Department of the Air Force. Air Force Research Laboratory. “High Power Microwaves.” AFRL Fact Sheet. January 1998. Online. Internet. <http://www.de.af.mil/Factsheets/HPMicro.html>.

United States. Department of the Air Force. Wright-Patterson AFB, OH. “The Execution and Prioritization of Repair Support Systems Summit.” Washington: January 2001.

United States. Department of Commerce. Office of Strategic Industries and Economic Security, Strategic Analysis Division. Industry Survey. Washington: 1998.

United States. Department of Commerce. Bureau of Export Administration. National Security Assessment of the High Performance Explosives and Explosives Component Industries. A Report for the U.S. Navy. Washington: GPO, June 2001.

United States. Department of Commerce. BXA Industry Survey. Washington: GPO, 2000.

United States. Department of Commerce. Office of Space Commercialization. Licensing of Commercial Remote Sensing Satellite Systems. Washington: GPO, 2000. Online. Internet. <http://www.ta.doc.gov/space/imaging/>.

United States. Department of Defense. Assistant Secretary of the Army for Financial Management and Comptroller. FY03 President's Budget Highlights. February 2002.

United States. Department of Defense. Center for Defense Information. "World-Wide Conventional Arms Trade (1994-2000): A Forecast and Analysis." December 1994.

United States. Department of Defense. Cohen, William S. The report of the Quadrennial Defense Review Section VII: Transforming US Forces for the Future.

United States. Department of Defense. Defense Science Board Task Force. "Preserving a Healthy and Competitive U.S. Defense Industry to Ensure our Future National Security." Final Briefing. 20 November 2000.

United States. Department of Defense. Defense Threat Reduction Agency. "Counter Proliferation Weapons Research and Development." Group briefing and discussion. 8 March 2002.

United States. Department of Defense. Defense Threat Reduction Agency. "Briefing to AY02 ICAF Munitions Seminar." 8 March 2002.

United States. Department of Defense. Design Criteria Standard. "Fuze Design, Safety Criteria for, MIL-STD-1316E." 10 July 1998.

United States. Department of Defense. DOD Instruction 3000.4, The Capabilities Based Munitions Requirements Process. Washington: 10 August 2001.

United States. Department of Defense. DOD Regulation 5000.2-R.

United States. Department of Defense. Office of the Secretary of Defense. "Annual Industrial Capabilities Report to Congress." March 2002.

United States. Department of Defense. "OSD AT&L (S&TS, Munitions) Advanced Energetics Workshop." Briefing. February 2000.

United States. Department of Defense. Strategic Environmental Research and Development Office. Energetic Materials Environmental Study. Washington: 1999.

United States. Department of Defense. Under Secretary of Defense for Acquisition, Technology and Logistics. "Insensitive Munitions." Memorandum. 26 January 1999.

United States. Department of Justice. "Protecting America's Critical Infrastructures: PDD 63." 8 February 1999. Online. Internet.
www.usdoj.gov/criminal/cybercrime/factsh.htm.

United States. Department of the Navy. "SLAM ER Missile Systems." Navy Fact Sheet. 28 November 2000. Online. Internet.
<http://www.chinfo.navy.mil/navpalib/factfile/missiles/wep-slam.html>.

United States. Department of the Navy. Naval Research Laboratory. Contracts Division. "Directed Energy Warfare Susceptibility and Hardening." Broad Agency Announcement. 1 January 2001. Online. Internet.
<http://heron.nrl.navy.mil/contracts/01baa/138.htm>.

United States. General Accounting Office. Report #GAO-01-163, Tactical Aircraft: Modernization Plans Will Not Reduce Average Age of Aircraft. Washington: GPO, 9 February 2001.

United States. General Accounting Office. "GAO Letter Report, Weapon Acquisition: Precision Guided Munitions in Inventory, Production and Development." 23 Jun 1995. Online. Internet. <http://www.fas.org/man/gao/gao9595.htm>.

United States. Title 10 U.S. Code 4532. The Arsenal Act.
United States. Trade Agreements Act of 1979, Chapter 13. Online. Law Links. 25 February 2002.
[http://resource.lawlinks.com/Content/Legal_Research/US_code/Title_19/title\)19_13.htm](http://resource.lawlinks.com/Content/Legal_Research/US_code/Title_19/title)19_13.htm).

Velocci, Anthony L. Jr. "Merger-Review Policy: Deciphering the Record." Aviation Week & Space Technology 3 December 2001.

Voth, Peter. "AGM-142 Raptor." Federation of American Scientists, Military Analysis Network 10 December 2001. Online. Internet. <http://www.fas.org/man/dod-101/sys/smart/agm-142.htm>.

Wall, Robert, Fulghum, David A. "Upgrades Planned for Existing Cache." Aviation Week and Space Technology 25 September 2000.

Wall, Robert. "War Drains U.S. Military Aircraft and Munitions." Aviation Week and Space Technology 18 February 2002.

The White House. Office of the Press Secretary. Fact Sheet. "Foreign Access to Remote Sensing." 10 March 1994. Online. Internet.
<http://www.fas.org/irp/offdocs/pdd23-2.htm>.

Wilson, Jim. "E-Bomb." Popular Mechanics Zone. Online. Internet.
<http://popularmechanics.com/science/military/2001/9/e-bomb>.

Wolfe, Frank. "DoD Proposes Tripling JDAM Production to Replenish Stocks." Defense Daily International 11 January 2002.

Wortzel, Larry M., PhD. "Export Controls and National Security in an Age of Globalization." Heritage Lectures 25 February 2002. Online. Internet. <http://www.heritage.org/library/lecture/h1652.html>.

Zimmerman, Eric A., Contractor, Aging Aircraft Program Office. "ASC/AAA Spares Requirement Review Board Process." July 2000.